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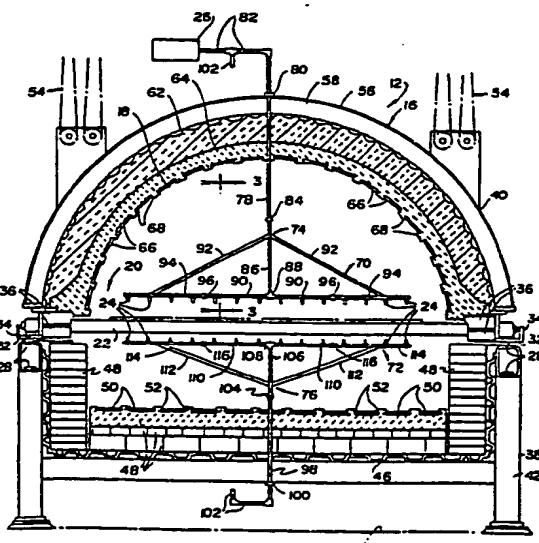
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(54) Glass sheet roller conveyor furnace including gas jet pump heating.

(57) A roller conveyor furnace (12) is disclosed as including at least one gas jet pump (24) for providing forced convection heating of glass sheets during conveyance on rolls (22) of the furnace conveyor (20). A source (26) of compressed gas located externally of the furnace is communicated with the gas jet pump to supply a primary gas flow thereto and induce an amplified extent of a secondary gas flow in order to provide a combined flow of heated gas that produces the forced convection heating. Upper and lower arrays (70,72) of the gas jet pumps are disclosed as being usable separately or in cooperation with each other in one embodiment to maintain temperature uniformity and glass sheet planarity. Each array includes an associated conduit support (74,76) that mounts the gas jet pumps thereof in a spaced relationship transverse to the direction of conveyance either above or below the conveyor rolls. In another embodiment, the compressed gas supplied to the gas jet pumps (24) is heated to provide the primary source for heating the furnace. One gas jet pump utilized comprises a simple jet opening, while another pump comprises a restricted opening and a contoured surface along which the primary gas flow is guided, and a further pump includes a deflector that initially guides the primary gas flow from a restricted opening along the contoured surface.



GLASS SHEET ROLLER CONVEYOR FURNACE  
INCLUDING GAS JET PUMP HEATING

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TECHNICAL FIELD

This invention relates to furnaces for heating  
glass sheets on a roller conveyor in preparation for  
10 a processing operation such as tempering, bending,  
bending and tempering, or filming, etc.

BACKGROUND ART

15 United States Patents 3,806,312; 3,934,970; 3,947,-  
242; and 3,994,711 disclose furnaces including roller  
conveyors for heating glass sheets while conveyed in a  
generally horizontal orientation through an associated  
heating chamber. Convection between both the top and  
20 bottom surfaces of the conveyed glass sheets and the  
gas within the heating chamber performs a certain ex-  
tent of the heating. Conduction between heated rolls  
of the conveyor and the bottom surface of each con-  
veyed glass sheet also provides some of the heating.  
25 In addition, the preferred construction of these fur-  
naces utilizes electric resistance elements both above  
and below the conveyor rolls such that both the top and  
bottom surfaces are also heated by radiation. Of  
course, the rolls shield the bottom surface of each  
30 glass sheet to some degree from the resistance ele-  
ments located below the conveyor and thereby decrease  
the radiant energy that is transferred to the glass.

It is important to maintain glass sheets generally  
35 planar during heating on roller conveyors regardless of

whether the final product is to be flat glass for architectural use or bent glass such as used with vehicles. Due to conduction of heat from the rolls, the bottom surface of the glass sheet heats more rapidly causing the glass sheet to be convex at its bottom surface and causing the central area which remains in contact with the rolls to overheat which warps the glass sheet and also results in roll print at the central area. Flat glass is usually tempered or is first coated with a metal film and then tempered by rapid cooling of the heated glass sheet which cannot deviate too much from a uniform temperature if the final product is to be flat. Depending upon the type of bending equipment utilized, it can be difficult to provide an accurate control of the shape of bent glass if the heated glass sheet deviates from a uniform temperature by too great an extent.

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Heating of glass sheets to a desired temperature for processing is most preferably performed as rapidly as possible to keep the furnace short to lower heat losses and so as to provide heating with as little distortion as can be achieved.

United States Patents 3,778,244; 4,202,681; and 4,222,763 disclose bending stations including gas jet pumps utilized in association with roller conveyor type furnaces within which glass sheets are heated. These gas jet pumps are supplied pressurized gas through a nozzle opening so as to effect a primary gas flow which induces a secondary gas flow in order to support a heated glass sheet in preparation for bending or to provide the bending against a curved surface located above the roller conveyor.

United States Patents 4,059,426 and 4,059,427 disclose glass sheet heating furnaces of the gas support type wherein gas jet pumps pressurize a plenum chamber below a support bed having passages through which the pressurized gas escapes to support a glass sheet above the bed for conveyance therealong and heating within the furnace heating chamber. Pressurized gas fed to the gas jet pumps from outside of the heating chamber is throttled to provide a primary gas flow along a curved surface so as to thereby induce a secondary gas flow of a greatly amplified extent for pressurizing the chamber that feeds the gas through the passages of the support bed on which the glass sheets are conveyed. Also, the 4,059,426 patent additionally discloses such gas jet pumps positioned above the gas support bed so as to direct heated gas flow downwardly against the top surfaces of glass sheets conveyed on the gas support bed. Electrical resistance heating of the compressed gas supplied to such jet pumps provides the energy input to maintain the heated condition of the gas within this furnace.

United States Patent 4,204,854 discloses gas jet pumps utilized with a glass sheet heating furnace of the roller conveyor type so as to blow heated glass sheets upwardly off of the conveyor rolls against a holder positioned above the conveyor in preparation for depositing of the glass sheet on a mold for bending.

United States Patent 4,282,026 discloses a glass sheet bending system in which a heated glass sheet is lifted upwardly from a horizontal conveyor and

supported by a differential gas pressure against a downwardly facing surface of a holder in preparation 5 for bending. Termination of the differential gas pressure releases the heated glass sheet so as to drop downwardly onto a mold of a curved shape for bending. An actuator moves the mold to a quench unit in a time to control the extent of bending be- 10 fore tempering of the glass sheet.

## DISCLOSURE OF INVENTION

An object of the present invention is to provide 15 forced convection heating of glass sheets during conveyance thereof on a furnace roller conveyor to provide a uniform temperature and a generally planar condition of the conveyed sheets during heating.

20 Another object of the invention is to provide forced convection heating of glass sheets during conveyance thereof on a furnace roller conveyor in order to provide rapid heating thereof to a desired temperature.

25 In carrying out the above objects as well as other objects, a glass sheet heating furnace constructed in accordance with the present invention includes a housing defining a heating chamber and 30 also includes a roller conveyor having horizontally extending rolls for conveying glass sheets horizontally through the heating chamber for heating of the glass sheets. At least one gas jet pump of the furnace is located within the heating chamber, and a 35 source of compressed gas located externally of the

heating chamber is communicated with the gas jet pump to supply a primary gas flow thereto in order 5 to induce a secondary gas flow and provide a combined flow of heated gas. The gas jet pump is oriented such that the combined flow of heated gas therefrom is directed toward the conveyor to provide forced convection heating of conveyed glass 10 sheets during conveyance thereof on the rolls of the conveyor with the bottom glass sheet surfaces in continuous engagement with the conveyor rolls.

One embodiment of the gas jet pump comprises a 15 simple jet opening that is fed compressed gas from the external source to provide a jet of primary gas flow that induces the secondary gas flow to provide the combined flow of heated gas that produces the forced convection heating. Another embodiment of the gas jet pump includes a restricted opening that is fed compressed gas from the external source and also includes a contoured surface along which the primary gas flow from the opening is guided to induce the secondary gas flow and 25 thereby provide the combined flow of heated gas that produces the forced convection heating. Such a gas jet pump provides a much greater extent of secondary gas flow than a simple jet opening and thus provides a greater extent of forced convection 30 heating of glass sheets during conveyance thereof on the rolls of the conveyor. A further embodiment of the gas jet pump also includes a restricted opening as well as a contoured surface along which the primary gas flow from the opening is guided and additionally includes a deflector that initially guides 35 the primary gas flow along the contoured surface.

Best results are achieved with an array of the gas jet pumps spaced from each other transversely to the direction of conveyance so as to uniformly heat each conveyed glass sheet over its entire width. Both upper and lower arrays of the gas jet pumps are provided in the furnace embodiments disclosed. The upper array of gas jet pumps is located above the roller conveyor to provide forced convection heating of top surfaces of conveyed glass sheets by downward gas flow. The lower array of gas jet pumps is located below the roller conveyor to provide forced convection heating of the bottom surfaces of conveyed glass sheets by upward gas flow between the rolls. Each array is disclosed as including a conduit support that mounts the gas jet pumps thereof above or below the conveyor within the heating chamber and also supplies the compressed gas to the jet pumps from the external source located outside of the heating chamber. An adjuster of each conduit support is provided to permit vertical adjustment thereof and appropriate positioning of the array of gas jet pumps mounted thereby with respect to the conveyor.

In one preferred furnace embodiment disclosed, the furnace includes electric resistance elements supported on the housing to heat the heating chamber and the forced convection heating provided by the gas jet pump operation is utilized to provide a uniform temperature and maintain planarity of each heated glass sheet in preparation for processing. Mounting of the gas jet pumps on the conduit supports has particular utility with this embodiment since minimal shielding of conveyed glass sheets from radiant heating results.

Either the upper or lower arrays of gas jet pumps can be utilized without the other to provide the forced convection heating that provides a uniform temperature and maintains planarity of glass sheets being heated during conveyance on the furnace roller conveyor. Conventional heating of clear glass will usually involve the use of the upper array of gas jet pumps to provide forced convection heating of the top glass surface to balance the conductive heat supplied to the bottom glass surface by contact with the conveyor rolls. In certain instances, the lower array of gas jet pumps can be utilized without the upper one to provide forced convection heating of the bottom glass surface such as may be necessary when the conductive heating of the bottom surface by the rolls is not as great as the amount of radiant heat shielding of the bottom surface by the rolls. Also, when a glass sheet with a metal film on its top surface is being conveyed, the film results in a greater amount of heating of the top surface and forced convection heating of the bottom surface by the lower array of gas jet pumps is then particularly desirable to provide additional heating of the bottom surface.

In another preferred furnace embodiment disclosed, the furnace includes a plurality of the gas jet pumps spaced along the length of the conveyor within the heating chamber. A heater also provided heats the compressed gas supplied by the external source to the gas jet pumps to provide the primary source for heating the furnace. The

primary gas flow of heated gas to each gas jet pump induces a secondary gas flow to provide a

5 combined flow of heated gas that produces the forced convection heating. Upper and lower arrays of the gas jet pumps are mounted by the conduit supports along the length of the conveyor, and insulation surrounds each gas jet pump to prevent

10 radiant heating of conveyed glass sheets by the conduit supports through which the heated gas is supplied to the gas jet pumps.

With both furnace embodiments, adjustment of the

15 mass flow rate of compressed gas fed to the upper and/or lower arrays of gas jet pumps is possible to provide the desired heating of the top and bottom glass surfaces. Such adjustment is also utilized to prevent upward gas flow from lifting the conveyed

20 glass sheets upwardly off the conveyor, i.e. the bottom glass surface is maintained in engagement with the conveyor rolls throughout the heating.

The objects, features, and advantages of the

25 present invention are readily apparent from the following detailed description of the best modes for carrying out the invention when taken in connection with the accompanying drawings.

FIGURE 1 is a schematic side elevation view of a glass sheet processing system including a roller conveyor furnace that incorporates gas jet pump heating in accordance with the present invention;

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5 FIGURE 2 is a cross-sectional view through the furnace taken generally along line 2-2 of FIGURE 1 and illustrates upper and lower arrays of gas jet pumps that provide forced convection heating of glass sheets during conveyance on the roller conveyor of the furnace;

10 FIGURE 3 is a side elevation view taken generally along line 3-3 of FIGURE 2 to further illustrate the upper and lower arrays of gas jet pumps;

15 FIGURES 4, 5, and 6 illustrate different types of gas jet pumps that can be utilized to provide the gas jet pump heating of glass sheets being conveyed on the roller conveyor of the furnace;

20 FIGURE 7 is a schematic side elevation view of another glass sheet processing system that includes a roller conveyor furnace incorporating gas jet pump heating in accordance with the present invention; and

25 FIGURE 8 is a cross-sectional view taken generally along line 8-8 in FIGURE 7 and illustrates upper and lower arrays of gas jet pumps that provide forced convection heating of glass sheets during conveyance on the roller conveyor of the furnace.

30 BEST MODES FOR CARRYING OUT THE INVENTION

Referring to FIGURE 1 of the drawings, a glass sheet processing system indicated generally by reference numeral 10 is illustrated schematically. System 10 includes a glass sheet heating furnace 12

constructed in accordance with the present invention and also includes a processing station 14 for processing heated glass sheets to provide bending, tempering, bending and tempering, or filming, etc.

Furnace 12 illustrated in FIGURES 1 and 2 includes a housing 16 defining a heating chamber 18 in which glass sheets are heated. A roller conveyor 20 of the furnace includes horizontally extending rolls 22 for conveying glass sheets G through the heating chamber for heating thereof from room temperature to a desired temperature for processing at the processing station 14. Furnace 12 includes at least one gas jet pump 24 within the heating chamber and, as is more fully hereinafter described, the furnace preferably includes a plurality of the gas jet pumps so as to provide uniform heating. A source 26 of compressed gas is located externally of the heating chamber and communicated with each gas jet pump 24 to supply a primary gas flow thereto in order to induce a secondary gas flow and provide a combined flow of heated gas within the heating chamber. Each gas jet pump 24 is oriented such that the combined flow of heated gas therefrom is directed toward the conveyor 20 to provide forced convection heating of conveyed glass sheets during conveyance thereof on the rolls 22 of the conveyor with the bottom glass sheet surfaces in continuous engagement with the conveyor rolls.

Roller conveyor 20 of the furnace 12 illustrated in FIGURES 1 and 2 is preferably of the type disclosed by United States Patents 3,806,312; 3,907,132; 3,934,-

970; and 3,994,711 wherein, a pair of continuous drive loops 28 respectively support and frictionally drive the opposite ends of the conveyor rolls 22. Drive loops 28 are preferably embodied as toothed chains of the link type connected by pins and are received by associated toothed wheels 30 at opposite ends of the furnace 12 on each of its lateral sides. Driving of the toothed wheels 30 slidably moves an upper reach of each drive loop 28 over an associated support surface 32 located outside of the furnace heating chamber at the adjacent lateral side of the furnace. Roll positioners 34 project upwardly from the support surfaces 32 and capture central pins of the roll ends such that movement of the drive loops 28 frictionally drives the roll ends to provide rotation thereof and consequent conveyance of glass sheets supported by the rolls within the heating chamber 18. The ends of each roll 22 project outwardly from the heating chamber 18 through upper and lower heat seals 36 of the housing 16 for the support and frictional driving by the drive loops 28.

Furnace housing 16 illustrated in FIGURE 2 is of a two-part type including a fixed lower section 38 and a vertically movable upper section 40. A framework 42 of the lower section 38 has legs resting on the floor 44 and supports a corrugated metal liner 46 which in turn supports ceramic blocks 48 that insulate the lower housing section. Electric resistance elements 50 secured by T-shaped ceramic retainers 52 are supplied electrical power to provide heating of the chamber 18 from below the roller conveyor 20 which is located between the lower and upper housing sections 38 and 40.

Above the roller conveyor 20, the upper housing section 40 is supported on an unshown suspension frame-  
5 work by counterbalances 54 in the manner disclosed by United States Patent 3,947,242. Upper housing section 40 has a generally semicircular shape and includes an outer metal skin 56 supported on a gen-  
10 erally semicircular metal frame 58. Outer and in-  
ner ceramic blocks 62 and 64 of generally semicircu-  
lar shapes are located within the frame 58 and pro-  
vide insulation to the upper housing section 40.  
Electric resistance elements 66 are secured by T-  
shaped ceramic retainers 68 and are supplied elec-  
15 trical power to provide heating of the chamber 18  
above the roller conveyor 20. The semicircular  
shape of the upper housing section 40 provides much  
more uniform radiant heating of the conveyed glass  
sheets than is possible with a downwardly opening  
20 U shape with right angle corners.

As seen in FIGURES 1, 2, and 3, furnace 12 in-  
cludes upper and lower arrays 70 and 72 of the gas  
jet pumps 24 just upstream from the processing sta-  
25 tion 14. Each array 70 and 72 includes a plurality  
of the gas jet pumps 24 spaced transversely to the  
direction of conveyance. The upper array 70 of gas  
jet pumps 24 is located above the roller conveyor  
20 to provide forced convection heating of the top  
30 surfaces of conveyed glass sheets. The lower array  
72 of gas jet pumps 24 is located below the roller  
conveyor 20 to provide forced convection heating of  
the bottom surfaces of conveyed glass sheets. Forced  
convection heating provided by the upper array 70  
35 and/or the lower array 72 is utilized to provide a

uniform temperature of the top and bottom surfaces of each glass sheet and to maintain the planarity of the conveyed glass sheets in preparation for processing.

Upper and lower conduit supports 74 and 76 shown in FIGURES 2 and 3 respectively mount the 10 upper and lower arrays 70 and 72 of gas jet pumps above and below the roller conveyor 20. Upper conduit support 74 includes a conduit 78 that projects downwardly through a suitable hole in the upper housing section 40 and through an adjuster 80 which includes a suitable collar fixed to the upper housing 15 section and also includes an associated lock screw such that the upper array of gas jet pumps can be adjusted vertically to the required elevation with respect to the roller conveyor 20. An upper end of 20 the conduit 78 is connected by conduits 82 to the source 26 of compressed gas, and the lower end of conduit 78 is connected to a union 84. A vertically extending conduit 86 has an upper end connected to the union 84 and a lower end connected to a T fitting 25 88 from which laterally extending conduits 90 project in opposite directions. Just below the union 84, angular conduits 92 are connected to the conduit 86 and extend downwardly and outwardly in a lateral direction to conduits 94 whose inner ends are connected 30 by unions 96 to the outer ends of the conduits 90. Conduit 86 as well as both of the conduits 92 supply compressed gas to the conduits 90 and 94 so as to provide a uniform distribution of the compressed 35 gas to the upper array 70 of transversely spaced gas jet pumps 24.

The lower conduit support 76 shown in FIGURE 2 includes a conduit 98 that projects upwardly through 5 a suitable opening in the lower housing section 38 and through an adjuster 100 which includes a collar mounted on the framework 42 and also includes an associated lock screw so as to permit vertical adjustment of the lower array 72 of gas jet pumps 24 with 10 respect to the roller conveyor 20. A lower end of the conduit 98 is connected by suitable conduits 102 to the one conduit 82 connected to the source 26 of compressed gas, and an upper end of the conduit 98 is connected to a union 104 within the heating chamber 18. A conduit 106 has a lower end connected to 15 the union 104 and an upper end connected to a T fitting 108 that is also connected to a pair of conduits 110 projecting laterally in opposite directions from each other. Just above the union 104, angular conduits 112 are connected to the conduit 106 and extend 20 upwardly and outwardly in opposite lateral directions therefrom for connection to conduits 114 whose inner ends are connected by unions 116 to outer ends of the conduits 110. Conduit 106 and the conduits 112 supply 25 compressed gas to the conduits 110 and 114 so as to provide a uniform distribution of the compressed gas to the gas jet pumps 24 spaced transversely to the direction of glass sheet conveyance.

30 With the construction of the conduit supports 74 and 76 described above, minimal radiant heat shielding of the top and bottom surfaces of conveyed glass sheets is present as a result of the gas jet pumps 24 while still permitting the forced convection heating 35 achieved with the gas jet pumps. As previously

mentioned, the upper and lower arrays 70 and 72 of gas jet pumps can be operated separately or together 5 under the control of suitable valving to provide top and/or bottom forced convection heating that provides a uniform glass temperature and ensures glass planarity just upstream from the processing station 14.

10 Different embodiments of the gas jet pumps 24 which can be utilized will now be described with reference to FIGURES 4, 5, and 6.

As seen in FIGURE 4, the gas jet pump 24a is 15 provided on a conduit C which is fed compressed gas from the external source previously described. A simple jet opening 118 of the conduit C provides a jet of primary gas flow as illustrated by arrow 120 for inducing a secondary gas flow, as illustrated 20 by arrows 122, of gas within the heating chamber in order to provide a combined flow of heated gas. Jet opening 118 is oriented such that the combined flow of heated gas from the gas jet pump 24a is directed toward the conveyor to provide forced convection 25 heating of conveyed glass sheets during conveyance thereof on the rolls of the conveyor with the bottom glass sheet surfaces in continuous engagement with the conveyor rolls.

30 Another embodiment of the gas jet pump is illustrated in FIGURE 5 and identified by reference numeral 24b. A connector 124 of the gas jet pump 24b includes a first threaded end 126 that is threaded into a conduit which is fed compressed 35 gas as previously described. A second threaded end 128 of the connector 124 is threaded into a threaded

hole of a generally pointed member 130 that defines a contoured surface 132 between its larger and smaller ends with a round cross-section therebetween.

5 An axial passage 134 of the connector 124 feeds compressed gas to one or more radial passages 136 from which the gas flows radially to an annular space 138 defined by an annular groove at the large end of the

10 pointed member 130 adjacent the open end of the threaded hole therein which receives the threaded end 128 of the connector. A restricted opening 140 of an annular shape is defined by an axial shoulder of the connector 124 and an axial surface at the large

15 end of the member 130 so as to feed the compressed gas outwardly along the contoured surface 132 about its complete circumference. The tendency of gas flowing along a surface to continue flowing therealong despite contours thereof deviating from a

20 straight line provides a primary gas flow as indicated by arrows 142 along the contoured surface 132. This primary gas flow induces a secondary gas flow as illustrated by arrows 144, of gas within the heating chamber in order to provide a combined flow

25 of heated gas. The orientation of the gas jet pump 24b is such that the combined flow of heated gas therefrom is directed toward the conveyor to provide forced convection heating of conveyed glass sheets during conveyance thereof on the rolls of the conveyor

30 with the bottom glass sheet surfaces in continuous engagement with the conveyor rolls. Pointed member 130 is adjustably threaded on the connector 124 to adjust the size of the restricted opening 140 and thereby control the extent of primary gas flow that

35 is fed through the pump to induce the secondary gas

flow. A lock screw 146 received by the pointed end of the member 130 is threaded into engagement with 5 the axial surface of the threaded end 128 on the connector to secure the pointed member in any adjusted position.

Gas jet pump 24c illustrated in FIGURE 6 is 10 generally similar to the gas jet pump 24b shown in FIGURE 5 and, as such, like reference numerals are applied to like components thereof and have the same structure and operation except as will be noted. Gas jet pump 24c includes an annular radial flange 15 148 that projects outwardly from the connector 124 at the large end of the pointed member 130. An annular guide 150 projects radially from the flange 148 in order to initially guide the primary gas flow illustrated by arrows 142 along the contoured surface 20 132 of the pointed member. The primary gas flow then induces the secondary gas flow within the heating chamber as illustrated by arrows 144 in the same manner previously described.

25 A much greater extent of secondary gas flow in relationship to the extent of primary gas flow can be achieved with the type of gas jet pumps illustrated in FIGURES 5 and 6 than can be achieved with a simple jet opening type of pump as illustrated in 30 FIGURE 4. Secondary gas mass flow rates on the order of 20 times the mass flow rate of the primary gas can be achieved with the type of gas jet pumps shown in FIGURES 5 and 6. Thus, when this type of jet pump is used within a furnace wherein the secondary 35 gas flow is gas heated by radiant electric heating

or another type of heater within the furnace, no preheating of the compressed gas that supplies the 5 primary gas is necessary other than that which takes place during flow through the conduits that feed the pumps.

With reference to FIGURES 7 and 8, another 10 embodiment of a glass sheet processing system is indicated generally by reference numeral 10' and is identical to the previously described embodiment except as will be noted. As such, like reference numerals are applied to like components 15 thereof and the previous description is applicable such that no repetition thereof is necessary.

As seen in FIGURE 7, the furnace 12 of system 10' includes a plurality of the gas jet pumps 24 spaced along the length of the conveyor within the 20 heating chamber. A heater 152 (FIGURE 8) of any suitable type is also provided for heating the compressed gas that is supplied by the external source 26 to the gas jet pumps 24 within the heating chamber. Housing 16 of the system 10' does not include 25 any radiant heaters, like the previously described embodiment, or any other type of internal heater such that the heated and compressed gas supplied to the gas jet pumps 24 provides the primary source 30 for heating the furnace. During operation, the heated gas supplied to the gas jet pumps 24 provides a primary gas flow in order to induce a secondary gas flow to provide a combined gas flow of 35 heated gas that produces the forced convection heating. With this type of system, a certain amount of

start-up time is necessary before the heated gas supplied through the gas jet pumps 24 raises the furnace 5 ambient temperature to that required in order to provide heating of glass sheets for bending and/or tempering etc.

System 10' shown in FIGURES 7 and 8 includes upper and lower arrays 70 and 72 of the gas jet pumps 24 spaced along the length of the conveyor to provide the forced convection heating of both the top and bottom surfaces of the conveyed glass sheets as the bottom surfaces thereof are maintained in continuous 15 engagement with the conveyor rolls 22. Upper and lower conduit supports 74 and 76 mount the gas jet pumps 24 of the upper and lower arrays such that the combined flow of heated gas therefrom is directed toward the plane of conveyance. Schematically indicated insulation 154 of any suitable form surrounds 20 each gas jet pump 24 to prevent radiant heating of the conveyed glass sheets by the conduit supports 74 and 76 which are necessarily heated to a relatively high temperature by the heated gas flow there- 25 through to the gas jet pumps. Also, it will be noted that the upper housing section 40 of this furnace 12 has a downwardly opening U-shape with square corners rather than a semicircular shape as with the previously described embodiment. This square cornered 30 embodiment of the upper housing section 40 defines a heating chamber 18 of a smaller volume which allows the furnace ambient to be maintained at the required temperature with a smaller flow rate of heated gas supplied to the gas jet pumps 24.

Any one of the gas jet pump embodiments 24a, 24b, or 24c shown in FIGURES 4, 5, and 6 can be 5 utilized with the system 10' illustrated in FIGURES 7 and 8. However, it is preferable for the gas jet pumps 24 of system 10' to include a simple jet opening like the jet pump 24a but utilizing a nipple that is mounted on the associated conduit 10 support 74 or 76 to define the jet opening. Such jet pumps 24 project from the insulation 154 toward the conveyor a sufficient extent to allow the primary flow of heated gas supplied thereto to induce the secondary flow and thereby provide effective 15 operation.

With both of the systems 10 and 10' described above, the mass flow rates of heated gas from the gas jet pumps 24 must be limited to prevent the 20 heated glass sheets from being deformed downwardly between the conveyor rolls 22 and to prevent the glass sheets from being lifted upwardly such that their bottom surfaces disengage the conveyor rolls. In this regard, it should be noted that the upper 25 and lower arrays 70 and 72 of the gas jet pumps 24 preferably oppose each other in order to counteract the forces applied to the top and bottom surfaces of the glass sheets and thereby permit a greater amount of forced convection heating than 30 would otherwise be possible.

While the best modes for carrying out the invention have been described in detail, those familiar with the art to which this invention relates will 35 recognize various alternative designs and embodiments for practicing the invention as defined by the following claims.

## What is claimed is:

- 5        1. A glass sheet heating furnace comprising:  
a housing defining a heating chamber; a roller  
conveyor including horizontally extending rolls  
for conveying glass sheets horizontally through  
the heating chamber for heating thereof; at least  
10      one gas jet pump within the heating chamber; a  
source of compressed gas located externally of the  
heating chamber and communicated with the gas jet  
pump to supply a primary gas flow thereto in order  
to induce a secondary gas flow and provide a com-  
15      bined flow of heated gas; and said gas jet pump  
being oriented such that the combined flow of  
heated gas therefrom is directed toward the convey-  
or to provide forced convection heating of conveyed  
glass sheets during conveyance thereof on the rolls  
20      of the conveyor with the bottom glass sheet sur-  
faces in continuous engagement with the conveyor  
rolls.
- 25        2. A furnace as in Claim 1 wherein the gas jet  
pump comprises a jet opening that is fed compressed  
gas from said source.
- 30        3. A furnace as in Claim 1 wherein the gas jet  
pump comprises: a restricted opening that is fed  
compressed gas from said source, and a contoured  
surface along which the primary gas flow from said  
opening is guided to induce the secondary gas flow.
- 35        4. A furnace as in Claim 3 wherein the gas jet  
pump further includes a deflector that initially

guides the primary gas flow from the restricted opening along the contoured surface.

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5. A furnace as in Claim 1, 2, 3 or 4 which includes an array of the gas jet pumps spaced from each other transversely to the direction of conveyance.

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6. A furnace as in Claim 5 wherein the array of gas jet pumps is located above the roller conveyor to provide forced convection heating of the top surfaces of conveyed glass sheets.

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7. A furnace as in Claim 5 wherein the array of gas jet pumps is located below the roller conveyor to provide forced convection heating of the bottom surfaces of conveyed glass sheets.

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8. A furnace as in Claim 1, 2, 3 or 4 which includes upper and lower arrays of the gas jet pumps, the gas jet pumps of each array being spaced from each other transversely to the direction of conveyance, and the upper and lower arrays of gas jet pumps being respectively located above and below the conveyor or rolls to provide forced convection heating of both the top and bottom surfaces of conveyed glass sheets.

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9. A furnace as in Claim 8 further including upper and lower conduit supports that respectively mount the upper and lower arrays of gas jet pumps above and below the conveyor.

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10. A furnace as in Claim 1 which includes a plurality of the gas jet pumps spaced along the length

of the conveyor within the heating chamber, and a heater for heating the compressed gas supplied by 5 the external source to the gas jet pumps to provide the primary source for heating the furnace.

11. A furnace as in Claim 10 which includes upper and lower arrays of the gas jet pumps spaced 10 along the length of the conveyor, conduit supports that mount the gas jet pumps of the arrays, and insulation that surrounds each gas jet pump to prevent radiant heating of conveyed glass sheets by the conduit supports.

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12. A glass sheet heating furnace comprising: a housing defining a heating chamber; electric resistance elements supported by the housing within the heating chamber to provide heating thereof; a 20 roller conveyor including horizontally extending rolls for conveying glass sheets horizontally through the heating chamber for heating thereof; an array of gas jet pumps spaced from each other transversely to the direction of conveyance; a source of compressed 25 gas located externally of the heating chamber; a conduit support that mounts the array of gas jet pumps within the heating chamber and provides communication thereof with the compressed gas source to supply a primary gas flow to the pumps in order to induce a 30 secondary gas flow and provide a combined gas flow of heated gas; said gas jet pumps being oriented such that the combined flow of heated gas therefrom is directed toward the conveyor to provide forced convection heating of conveyed glass sheets during conveyance thereof on the rolls of the conveyor with the 35

bottom glass sheet surfaces in continuous engagement with the conveyor rolls; and each gas jet pump including a restricted opening that is fed compressed gas from said source and also including a contoured surface along which the primary gas flow from said opening is guided to induce the secondary flow.

10 13. A furnace as in Claim 12 further including an adjuster for vertically adjusting the conduit support and the array of gas jet pumps mounted on the conduit support.

15 14. A glass sheet heating furnace comprising: a housing defining a heating chamber; electric resistance elements supported by the housing within the heating chamber to provide heating thereof; a roller conveyor including horizontally extending rolls for conveying glass sheets horizontally through the heating chamber for heating thereof; an array of gas jet pumps located above the conveyor and spaced from each other transversely to the direction of conveyance; a source of compressed gas located externally of the heating chamber; a conduit support that mounts the array of gas jet pumps within the heating chamber and provides communication thereof with the compressed gas source to supply a primary gas flow to the pumps in order to induce a secondary gas flow and provide a combined gas flow of heated gas; said gas jet pumps being oriented such that the combined flow of heated gas therefrom is directed downwardly toward the conveyor to provide forced convection heating of the top surfaces of conveyed glass sheets during conveyance thereof on the rolls of the conveyor with the bottom

glass sheet surfaces in continuous engagement with the conveyor rolls; and each gas jet pump including

5 a restricted opening that is fed compressed gas from said source and also including a contoured surface along which the primary gas flow from said opening is guided to induce the secondary gas flow.

10 15. A glass sheet heating furnace comprising: a housing defining a heating chamber; electric resistance elements supported by the housing within the heating chamber to provide heating thereof; a roller conveyor including horizontally extending

15 rolls for conveying glass sheets horizontally through the heating chamber for heating thereof; an array of gas jet pumps located below the conveyor and spaced from each other transversely to the direction of conveyance; a source of compressed gas located externally

20 of the heating chamber; a conduit support that mounts the array of gas jet pumps within the heating chamber and provides communication thereof with the compressed gas source to supply a primary gas flow to the pumps in order to induce a secondary gas flow and provide

25 a combined gas flow of heated gas; said gas jet pumps being oriented such that the combined flow of heated gas therefrom is directed upwardly between the rolls of the conveyor to provide forced convection heating of the bottom surfaces of conveyed glass

30 sheets during conveyance thereof on the rolls of the conveyor with the bottom glass sheet surfaces in continuous engagement with the conveyor rolls; and each gas jet pump including a restricted opening that is fed compressed gas from said source and also including

35 a contoured surface along which the primary gas flow

from said opening is guided to induce the secondary gas flow.

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16. A glass sheet heating furnace comprising: a housing defining a heating chamber; electric resistance elements supported by the housing within the heating chamber to provide heating thereof; a 10 roller conveyor including horizontally extending rolls for conveying glass sheets horizontally through the heating chamber for heating thereof; upper and lower arrays of gas jet pumps respectively positioned within the heating chamber above and below the roller 15 conveyor; each array having gas jet pumps spaced from each other transversely to the direction of conveyance; a source of compressed gas located externally of the heating chamber; upper and lower conduit supports that respectively mount the gas jet pumps of 20 the upper and lower arrays and provide communication thereof with the compressed gas source to supply a primary gas flow to the pumps in order to induce a secondary gas flow and provide a combined gas flow of heated gas; each gas jet pump including a restricted opening that is fed compressed gas from said 25 source and also including a contoured surface along which the primary gas flow from said opening is guided to induce the secondary gas flow; said gas jet pumps of the upper array being oriented such that 30 the combined flow of heated gas therefrom is directed downwardly toward the top surfaces of conveyed glass sheets to provide forced convection heating thereof during conveyance of the glass sheets with the bottom surfaces thereof in continuous engagement with the 35 conveyor rolls; and the gas jet pumps of the lower

array being oriented such that the combined flow of heated gas therefrom is directed upwardly between

5 the conveyor rolls toward the bottom surfaces of conveyed glass sheets to provide forced convection heating thereof during conveyance of the glass sheets with the bottom surfaces thereof in continuous engagement with the conveyor rolls.

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17. A glass sheet heating furnace comprising: a housing defining a heating chamber; a roller conveyor including horizontally extending rolls for conveying glass sheets horizontally through the heating chamber for heating thereof; arrays of gas jet pumps spaced along the length of the conveyor within the heating chamber; each array including a plurality of gas jet pumps spaced from each other transversely to the direction of conveyance; a source of compressed

15 gas located externally of the heating chamber; a heater for heating gas supplied by the compressed gas source; conduit supports that mount the arrays of gas jet pumps within the heating chamber and provide communication thereof with the compressed gas

20 source to supply a primary gas flow of heated gas to the pumps in order to provide the primary source of heating the furnace; said primary gas flow inducing a secondary gas flow to provide a combined gas flow of heated gas; and said gas jet pumps being oriented

25 such that gas flow therefrom is directed toward the conveyor to provide forced convection heating of conveyed glass sheets during conveyance thereof on the rolls of the conveyor with the bottom glass sheet surfaces in continuous engagement with the conveyor

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35 rolls.

18. A furnace as in Claim 17 further including insulation that surrounds the gas jet pumps to prevent radiant heating of the conveyed glass sheets by the conduit supports, and the gas jet pumps projecting from the insulation toward the conveyor.

19. A glass sheet heating furnace comprising: a housing defining a heating chamber; a roller conveyor including horizontally extending rolls for conveying glass sheets horizontally through the heating chamber for heating thereof; upper and lower arrays of gas jet pumps spaced along the length of the conveyor within the heating chamber above and below the roller conveyor; each array including a plurality of gas jet pumps spaced from each other transversely to the direction of conveyance; a source of compressed gas located externally of the heating chamber; a heater for heating gas supplied by the compressed gas source; upper and lower conduit supports that respectively mount the gas jet pumps of the upper and lower arrays and provide communication thereof with the compressed gas source to supply a primary gas flow of heated gas to the pumps in order to provide the primary source of heating the furnace; said primary gas flow inducing a secondary gas flow to provide a combined gas flow of heated gas; each gas jet pump including a jet opening that is fed the heated and compressed gas; said gas jet pumps of the upper and lower arrays being oriented such that gas flows therefrom are respectively directed downwardly and upwardly toward the top and bottom surfaces of conveyed glass sheets to provide forced convection heating

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P-374

-29-

thereof during conveyance of the glass sheets with  
the bottom surfaces thereof in continuous engage-  
5 ment with the conveyor rolls; and insulation that  
surrounds the gas jet pumps to prevent radiant heat-  
ing of the conveyed glass sheets by the conduit  
supports, and the gas jet pumps of each array pro-  
jecting from the insulation toward the conveyor.

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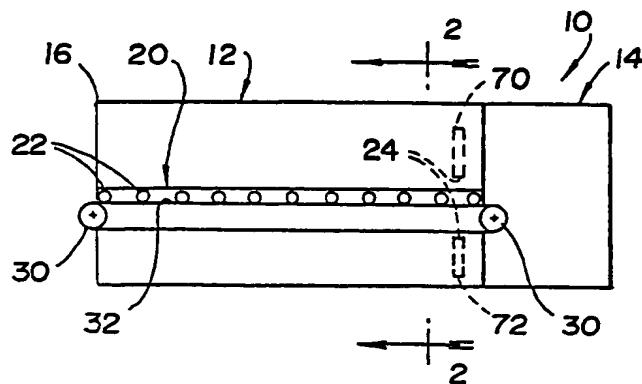


Fig. 1

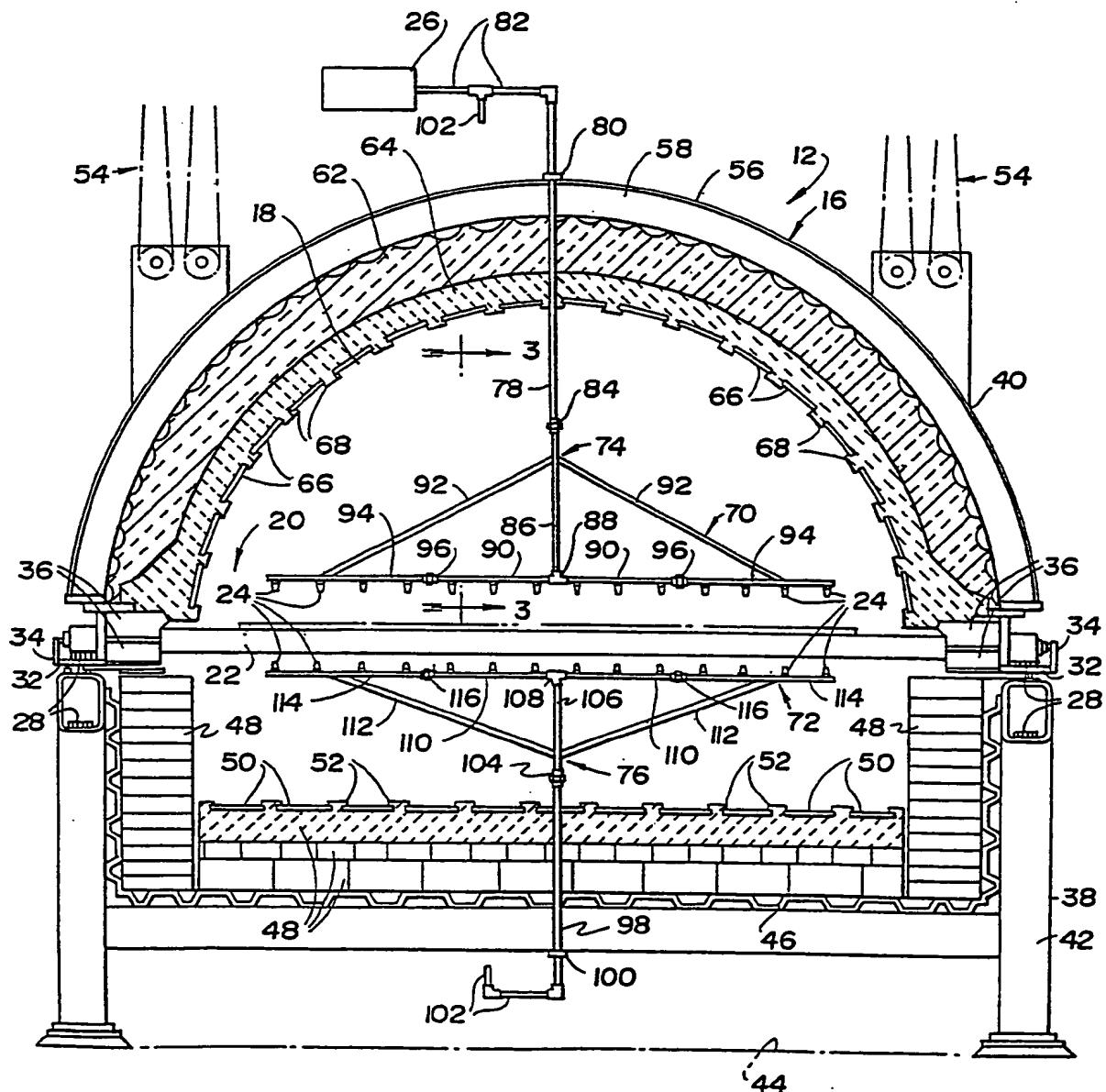


Fig. 2

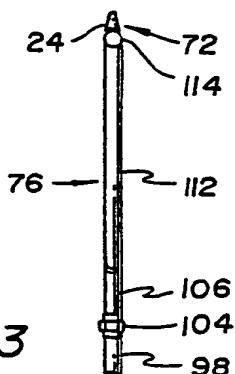
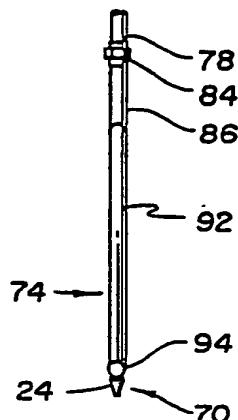


Fig. 3

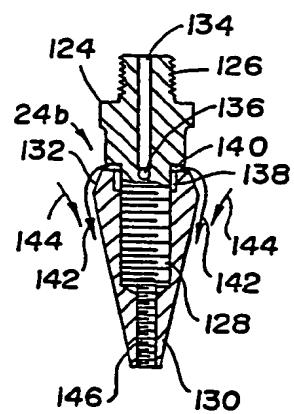
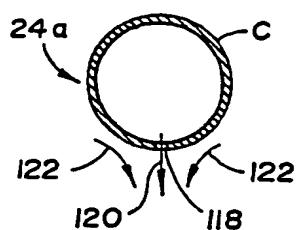


Fig. 4

Fig. 5

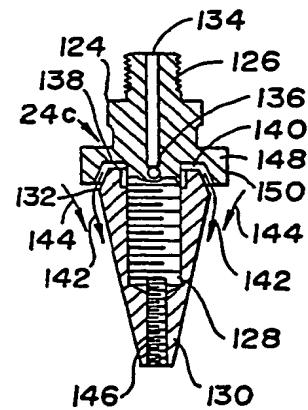


Fig. 6

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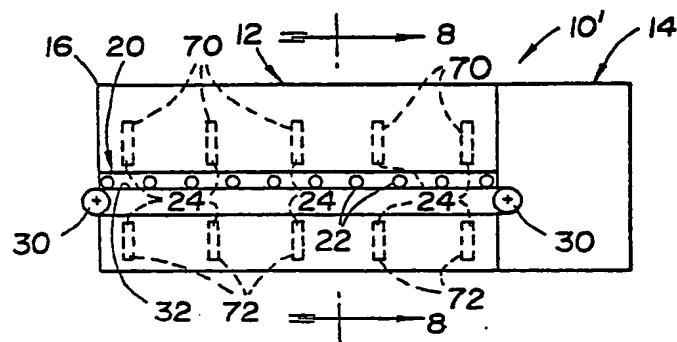


Fig. 7

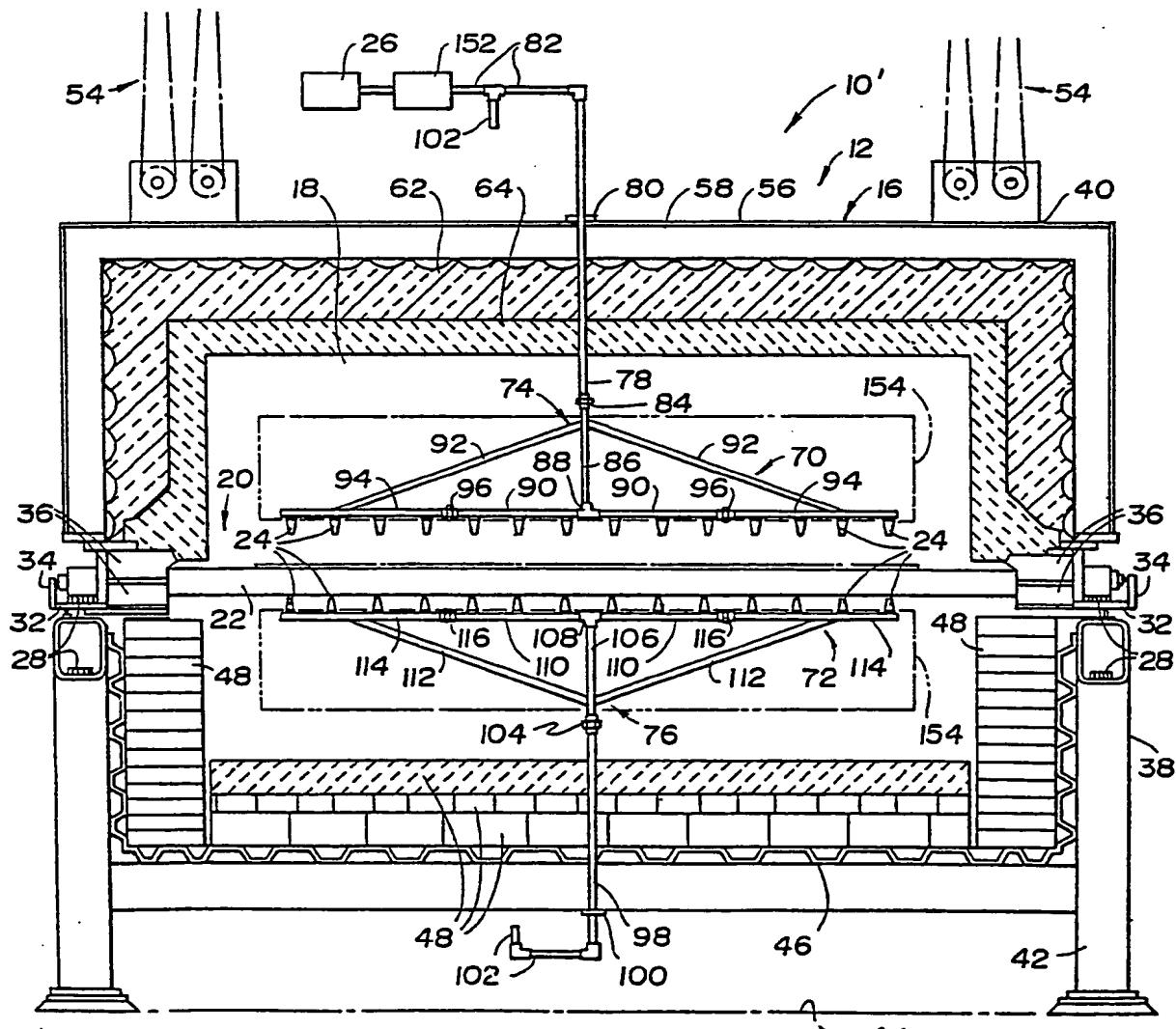


Fig. 8



European Patent  
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EUROPEAN SEARCH REPORT

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Application number

EP 82 30 0695

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl. 5)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
Y	<p><u>DE - A - 1 471 831 (GLAVERBEL)</u></p> <p>* figure 2; page 8, paragraphs 2,3; page 9 *</p> <p>&amp; US - A - 3 326 654</p> <p>---</p>	1,12, 14	C 03 B 29/04
Y,D	<p><u>US - A - 4 204 854 (McMASTER)</u></p> <p>* figures 10-13; column 6, lines 29-68; columns 7,8 *</p> <p>---</p>	1,12	
A,D	<p><u>US - A - 3 947 242 (McMASTER)</u></p> <p>* entire document *</p> <p>---</p>	1	TECHNICAL FIELDS SEARCHED (IntCl 5)
A	<p><u>FR - A - 1 580 190 (GLAVERBEL)</u></p> <p>* figure 8; page 7, left-hand column, paragraph 4; right-hand column, paragraph 1 and lines 1-3 from paragraph 4 *</p> <p>-----</p>		C 03 B 25/00 29/00
			CATEGORY OF CITED DOCUMENTS
			<p>X: particularly relevant if taken alone</p> <p>Y: particularly relevant if combined with another document of the same category</p> <p>A: technological background</p> <p>O: non-written disclosure</p> <p>P: intermediate document</p> <p>T: theory or principle underlying the invention</p> <p>E: earlier patent document, but published on, or after the filing date</p> <p>D: document cited in the application</p> <p>L: document cited for other reasons</p>
			<p>&amp;: member of the same patent family, corresponding document</p>
		The present search report has been drawn up for all claims	
Place of search	The Hague	Date of completion of the search	Examiner
		06-04-1982	VAN DEN BOSSCHE